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SURVIVAL AND DEVELOPMENT OF *LACANOBIA SUBJUNCTA* (GROTE & ROBINSON) (LEPIDOPTERA: NOCTUIDAE) LARVAE ON COMMON WEEDS AND CROP PLANTS OF EASTERN WASHINGTON STATE

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Abstract.—Ten common weed species, four tree fruit crops and four row crops were evaluated as hosts for larvae of *Lacanobia subjuncta* (Grote & Robinson), a noctuid moth pest of apple in eastern Washington. A separate comparative evaluation was made of the suitability of five varieties of apple as hosts for *L. subjuncta* larvae. Development was completed, from neonate larva to adult, on nine of ten weed species and seven of eight crops tested, indicating a broad potential host range for this insect. High rates of survival to adult, short developmental times, and large pupal weights were noteworthy on the weeds bindweed, dandelion, and mallow, and on potato. In the comparison of apple varieties, highest rate of survival to adult was with Red Delicious, greatest pupal weights were with Red Delicious, Gala, and Fuji, and shortest development times were with Gala and Golden Delicious. Strong seasonal variation (May versus July) was indicated in the quality of apple foliage as food for *L. subjuncta* larvae.

Key Words:—Insecta, *Lacanobia subjuncta,* host plant, apple, potato.

The noctuid moth *Lacanobia subjuncta* (Grote & Robinson) has recently become recognized as a significant pest of apple in eastern Washington and Oregon (Landolt 1998). The moth is widely distributed in North America (McCabe 1980), and has been present in irrigated areas of eastern Washington at least since the 1970s when it was collected in light traps in Yakima County by F. Howell (personal communication). Following an apparent increase in damage to apple attributed to cutworms (Warner 1996), *L. subjuncta* was identified as the principal noctuid pest on apple in eastern Washington and adjacent areas of Oregon (Landolt 1998).

Lacanobia subjuncta is bivoltine (McCabe 1980), with a flight of moths from late May into mid June and again from late July into mid September in eastern Washington (Landolt 1998, Hitchcox 2000). Larvae can be found on apple trees from early June through July and again from late August until October (Hitchcox 2000). It is thought that the insect overwinters strictly as a pupa in soil. Most larvae held in the laboratory and fed on apple foliage went through 6 instars before pupating, although several larvae went through 7 (Hitchcox 2000).

On apple, larvae of *L. subjuncta* are primarily foliage feeders and occasionally partially defoliate apple trees in commercial orchards. Damage to apple fruit occurs also, with larval feeding indicated by a hollowed out scoop in the surface of the apple that is somewhat characteristic of fruit feeding by other noctuids. The pest status for *L. subjuncta* on apple is due principally to their feeding on apple fruit and to problems in packing houses because of the presence of larvae on fruit (Warner 1998).

The recently acquired pest status of this insect on apple in Washington and Oregon is not understood. Hypotheses to explain this apparent change in pest status include 1) resistance to commonly used pesticides together with escape from natural enemies, 2) shifts in larval host plants, 3) changes in geographic distribution, 4) past misidentification of cutworms and fruit worms damaging apple, and 5) region-wide *L. subjuncta* moth population increases resulting in movement of moths into apple orchards. In order to consider the latter hypothesis, better information is needed on what plants may sustain *L. subjuncta* reproduction and may then be the principal host plants contributing to regional moth populations.

Larvae of *L. subjuncta* have been collected on a wide variety of plants, including trees, shrubs, and herbaceous plants (Godfrey 1972, Rings et al. 1992, Crumb 1956, Landolt 1998, and included references), indicating a potentially high degree of polyphagy. Recorded host plants include a number of agricultural crop plants, such as apple, cherry, peach, blueberry fruit and foliage, cabbage, asparagus, corn, and strawberry. However, the finding of larvae on a plant species is not necessarily a good indicator of suitable host plant status. The survival and development of larvae on plants along with the incidence of larvae on plants in the field would be better indicators of the importance of those plants as contributors to populations of *L. subjuncta*. In a preliminary assessment of host suitability of common weeds, Landolt (1998) demonstrated that *L. subjuncta* larvae could complete development on the weeds *Taraxacum officinale* Weber (dandelion), *Sonchus oleraceus* L. (annual sowthistle), *Convulvulus arvensis* L. (field bindweed), and *Malva neglecta* Wallr (comon mallow), but with low (20 to 28) percentages that survived to the adult stage.

Reported here are the results of experiments evaluating the ability of larvae of *L. subjuncta* to develop on foliage of a larger number of plant species (18) that are commonly encountered in irrigated areas of eastern Washington. This evaluation included determination of larval survival to pupation and adult emergence, larval development time, and pupal weights for *L. subjuncta* fed on the foliage of each plant species or variety. The objective of the study was to determine if these plants sustain complete development of newly hatched larvae through to adult, and might then contribute in the field to populations of *L. subjuncta*. Additionally, this study sought to identify plant species that might be further evaluated in the field as good hosts for *L. subjuncta*.

Materials and Methods

For each plant species and apple variety evaluated, data were obtained on survival of larvae to pupation and adult emergence, on larval development time (egg hatch to entry into soil), and on pupal weight. Plants evaluated were weed species *Sonchus asper* (L.) Hill (spiny sowthistle), dandelion, common mallow, field bindweed, *Cirsium arvense* (L.) Scop. (Canada thistle), *Helianthus annuus* L. (sunflower), *Chenopodium album* L. (lambsquarters), *Amaranthus retroflexus* L. (redroot pigweed), *Cardaria draba* (L.) Desv. (hoary cress), and *Kochia scoparia* (L.) Schrad. (kochia), the crop plants *Malus pumila* Mill. (apple, var. Fuji), *Pyrus communis* L. (pear, var. Bartlett), *Prunus armeniaca* L. (apricot), *Medicago sativa* L. (alfalfa), *Pisum sativum* L. (dry peas, var. Columbian), *Pisum sativum* L. (succulent peas, var. Oregon Trail), and *Solanum tuberosum* L. (potato, var. Russet Burbank). In another experiment, the apple varieties Fuji, Gala, Braeburn, Red Delicious, and Golden Delicious were evaluated as hosts for *L. subjuncta* larvae.

Adult *L. subjuncta* were obtained from a walk-in light trap at the Yakima

Agricultural Research Laboratory southeast of Yakima, Washington, in an area of commercial irrigated apple and pear orchards. Female moths from the light trap were held for 24 h in 50 ml plastic snap-cap vials for oviposition. Females that did not oviposit within that time period were assumed to be unmated and were moved to 900 ml plastic tubs with ventilated lids. These tubs contained sugar water on cotton balls, water on cotton balls, and two males that had been collected in the light trap. Some of these females subsequently laid fertile eggs. Newly eclosed larvae from egg batches were used for the following experiments.

The assay unit was a 300 ml waxed paper carton with a clear plastic lid, in which was placed plant foliage and one newly hatched larva. Cartons were held in a room on a 16:10 light:dark photoperiod, at 25° C and 60% RH. Plant foliage was added daily. Dried, brown, or moldy foliage was removed daily and new cartons were provided as needed when soiled by frass. When larvae reached about 3 cm in length, 2–3 cm of damp soil was placed in the carton and the plant foliage and larva were placed on top of this soil. Mature larvae entered the soil to pupate. Daily records were made of larval mortality, and larval movement into soil. Four to 6 days after larvae moved into soil, the soil was sifted to confirm the presence of a pupa, which was then weighed and transferred to a 30 ml paper cup held inside of the original waxed paper carton. Daily observations were made of pupae in order to record adult emergence. Data was not obtained on pupal duration because it was not possible to tell on what day a larva in the soil pupated. Disturbing the larva at that time might interfere with successful development.

Plant foliage was obtained in the field as needed by cutting plants with scissors and transferring foliage in 3.6 liter Ziplock® plastic freezer bags held in a cooler until return to the laboratory. Bags of foliage were held in a refrigerator at 3° C for up to seven days and were accessed daily to obtain foliage that was provided to larvae. For weeds, plants were selected from areas not sprayed with insecticides. For crop plants, growers were consulted for information on the timing and application of insecticides to avoid the collection of foliage with pesticide residues.

For each plant species or apple variety evaluated, three sets of five larvae were tested, with each set of five larvae originating from the egg batch of a different female moth. These three sets of larvae were staggered in time (three weeks apart) so that the individual plants evaluated were different for each set of five larvae.

Results

Larvae of *L. subjuncta* developed to pupation and adult emergence on the following weeds: spiny sowthistle, dandelion, bindweed, lambsquarters, mallow, Canada thistle, hoary cress, pigweed, and kochia (Table 1). No larvae survived to pupation on sunflower. Highest percentages of larvae surviving to pupation were fed on field bindweed. Larvae also developed to pupation and adult emergence on the following crop plants: cherry, apple, pear, alfalfa, potato, dry peas, and succulent peas (Table 1). No larvae survived to pupation on apricot. Highest percentages of larvae that pupated were on cherry, pear, potato and alfalfa. Larvae developed to pupation and adult emergence on all 5 apple varieties tested, but with significant differences in percentage of pupation among these varieties (Table 2). Significantly more larvae on Gala apple foliage died than did on Golden Delicious foliage.

Table 1. Mean (±SE) % pupation, adult emergence, pupal weight, and larval development times for *Lacanobia subjuncta* on 10 weedy plant and 8 crop species. Yakima, Washington, 2000.[a]

Plant species	% Pupated	% Adult	Pupal weight (mg)	Larval time (days)
Hoary Cress	66.7 ± 13.3c	60.0 ± 11.5	335 ± 8c	44.3 ± 1.6a
Common Mallow	80.0 ± 11.5bc	80.0 ± 11.5	363 ± 15b	26.1 ± 0.7c
Spiny Sowthistle	60.0 ± 20.0c	60.0 ± 20.0	436 ± 10a	26.9 ± 1.3bc
Dandelion	86.7 ± 6.7b	86.7 ± 6.7	392 ± 5b	25.7 ± 1.1bc
Canada Thistle	46.7 ± 6.7d	46.7 ± 6.7	249 ± 16e	28.7 ± 1.5bc
Common Sunflower	00.0 ± 00.0e	00.0 ± 00.0	—±—	—±—
Lambsquarter	85.0 ± 5.0b	73.4 ± 6.7	342 ± 11c	28.4 ± 1.6bc
Redroot Pigweed	70.0 ± 10.0d	70.0 ± 10.0	280 ± 10de	35.1 ± 2.9ab
Field Bindweed	100 ± 00.0a	100 ± 00.0	374 ± 8b	25.1 ± 0.6c
Kochia	40.0 ± 11.5d	40.0 ± 11.5	270 ± 12e	35.8 ± 2.7ab
Apple	66.7 ± 6.7c	66.7 ± 6.7	389 ± 7b	25.1 ± 0.7c
Pear	100.0 ± 00.0a	100 ± 00.0	333 ± 8c	26.5 ± 0.7bc
Cherry	93.4 ± 6.7ab	86.7 ± 6.7	323 ± 12cd	30.4 ± 1.1b
Apricot	00.0 ± 00.0e	00.0 ± 00.0	—±—	—±—
Potato	100 ± 00.0a	100 ± 00.0	377 ± 12b	24.7 ± 0.9c
Alfalfa	100 ± 00.0a	100 ± 00.0	297 ± 8d	29.9 ± 0.9b
Dry Peas	86.7 ± 13.3b	60.0 ± 23.0	285 ± 10de	31.3 ± 1.0b
Succulent Peas	73.4 ± 17.6bc	66.7 ± 24.0	286 ± 8d	29.8 ± 0.9b

[a] Means within a column followed by the same letter are not significantly different by Tukey's test at $P > 0.05$.

Mean development rates for larvae on weeds ranged from 25.1 days on bindweed to 44.3 days on hoary cress (Table 1). Other weeds supporting rapid development of larvae were spiny sowthistle, dandelion, mallow, lambsquarter, and Canadian thistle. Mean development rates for larvae on crop plants ranged from 24.7 days for potato to 31.3 days on dry peas (Table 1). Other crops supporting rapid development were apple and pear. Among apple varieties tested, mean development times were similar for Gala, Red Delicious, Fuji and Golden Delicious, while development on Granny Smith foliage was significantly slower (Table 2). Also of interest, mean development time for larvae on Fuji apple foliage was 25.1 ± 0.7 days when evaluated in the first study and was then 38.2 ± 1.0 days when evaluated in the second study, along with other apple varieties. The first evaluation used apple foliage collected during May, while the second evaluation used apple foliage collected during July.

Table 2. Mean (± SE) % pupation, adult emergence, pupal weight, and larval development times for *Lacanobia subjuncta* on foliage of 5 apple varieties. Yakima, Washington, 2000.[a]

Apple variety	% Pupated	% Adult	Pupal weight (mg)	Larval time (days)
Gala	40.0 ± 11.5b	33.3 ± 6.7	336 ± 30ab	37.4 ± 6.6bc
Red Delicious	73.3 ± 6.7ab	73.3 ± 6.7	387 ± 9a	38.0 ± 1.0bc
Fuji	73.3 ± 13.3ab	60.0 ± 11.5	357 ± 8ab	38.2 ± 1.0b
Golden Delicious	80.0 ± 20.0a	60.0 ± 11.5	321 ± 12b	35.7 ± 1.0bc
Granny Smith	66.7 ± 13.3ab	50.0 ± 10.0	284 ± 22b	47.7 ± 2.1a

[a] Means within a column followed by the same letter are not significantly different by Tukey's test at $P > 0.05$.

Mean pupal weights for *L. subjuncta* reared on weeds ranged from 249 mg on Canada thistle to 436 mg on spiny sowthistle (Table 1). Other relatively heavy mean pupal weights were 392 mg for larvae reared on dandelion, 374 mg for larvae reared on bindweed, and 363 mg for larvae reared on mallow. In addition to Canada thistle, pigweed and kochia yielded low pupal weights (Table 1). Mean pupal weights for larvae fed crop plants ranged from 285 mg for dry peas to 377 mg for potato and 389 mg for Fuji apple (Table 1). When mean pupal weights for apple varieties were compared, they ranged from 284 mg for larvae fed Granny Smith to 387 mg for larvae fed Red Delicious apple foliage (Table 2).

Discussion

These results clearly indicate a broad potential plant host range for *L. subjuncta* larvae and the potential for many plants in eastern Washington to contribute to regionally high population densities contributing to crop losses. Complete development from egg hatch to adult emergence was documented for 9 of the 10 weeds tested and 7 of the 8 crops tested, with sunflower and apricot not supporting larval development to pupation in this study. The plants selected for this study and supporting *L. subjuncta* development are taxonomically diverse and include the families Compositae, Cruciferae, Chenopodiaceae, Convulvulaceae, Malvaceae, Solanaceae, Rosaceae, and Leguminaceae. Undoubtedly, many other plants present in the region are probably equally suitable as hosts for *L. subjuncta.*

Just as the collection of larvae on a plant species is not proof that the species is a good host plant, the demonstrations of survival and development to adult on these plant species does not demonstrate that *L. subjuncta* utilizes these plants. Additional information on patterns of adult female egg laying, of larval dispersal and movement under field conditions, and of larval numbers on these and other plant species would be more conclusive in assessing the potential of these plants as hosts. Such studies clearly should incorporate not only common weeds but additional crops that have not been reported to be infested with *L. subjuncta.*

There were differences in the performance of larvae on Fuji apple foliage collected in May versus July that indicate possible seasonal variation in the suitability of foliage of apple as food for *L. subjuncta* larvae. There are two broods of *L. subjuncta* in Washington, with most larvae feeding in June/July and again in August/September (Hitchcox 2000). Larvae reared on Fuji apple foliage in May developed more rapidly and yielded larger pupae than larvae reared on Fuji apple in July. Despite these possible differences in apple suitability as a host for *L. subjuncta,* larvae are readily found on apple in the field during both time periods (Hitchcox 2000). Such differences in host suitability could be due to a variety of factors, such as accumulated leaf chemical defenses, increases in average leaf age, accumulated responses to disease and herbivore challenges, and nutritional changes in leaves. There is potential for much variation in foliage quality as food for larvae for each of the plant species tested and care must be exercised in using the data presented here for comparative purposes among plant species.

Also of concern is the potential impact of the apparent variance of plant suitability as food for *L. subjuncta* larvae on phenology models used in IPM programs for apple orchards. Such models may be used to predict *L. subjuncta* egg hatch for the purpose of accurately timing pesticide applications. If larval development rates are dependent in part on seasonal parameters affecting plant physiology, these must be incorporated into insect developmental models. Also, differential rates of development on different host plants will contribute to variance in adult emergence, oviposition, and egg hatch when multiple plants are used as hosts.

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